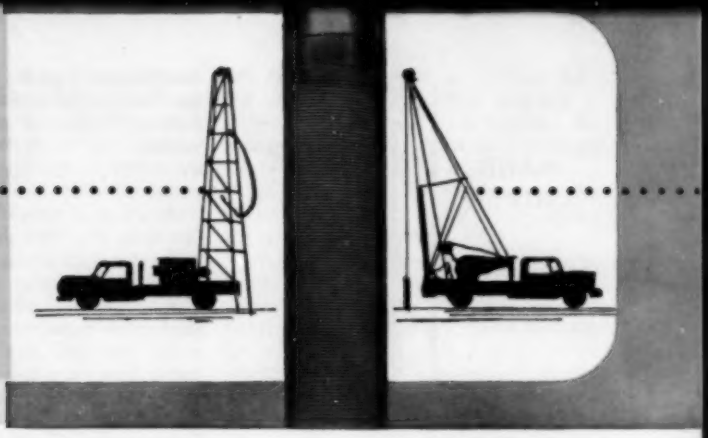
The Johnson National DRILLERS JOURNAL



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EVERDUR AND STAINLESS STEEL WELL-POINTS

Improve Yield and Life of Small Wells

The development of drive well-points made entirely of corrosion-resistant metals, Everdur and stainless steel, has widened the field of practical use of small-diameter screens in both shallow and deep wells. Everdur and stainless steel well-points provide permanent screens for small wells. They withstand the attack of corrosive waters and they can be acid treated in place if they become incrusted. They pretty well do away with the need for periodic removal and replacement — a common practice with the older types of well points. Everdur drive well-points have been on the market for more than 15 years. Stainless steel well-points have come along more recently, their manufacture having been started some four years ago.

Well-Point Defined

The term "well-point" has been used over the years to describe a small-diameter well screen fitted with a solid, pointed bottom and designed to be driven into the earth like a stake. For certain applications, however, well-points are also provided with a check valve or self-closing bottom in place of the solid steel point. This arrangement permits using hydraulic means to wash or jet the screens into place. The two different designs of well-points to fit distinct methods of installation require that we refer to each type by a suitable descriptive name. Thus, well-points designed to be driven into the earth are called "drive well-points." Those designed to be sunk by jetting are called "jet well-points." Since jet well-points can only be used to advantage under certain conditions, drive well-points are, by far, the more commonly used.

The screen body of a drive well-point has to be stiff and strong enough to withstand the force of driving. To provide this strength, well-points have been made for many years with perforated steel pipe as the base of the screen body. Jackets of brass gauze, perforated brass sheet and slotted brass tubing are put around or slipped over the pipe base. These jackets provide the screen openings of the size required to hold out the sand of the water-bearing formation and permit sand-free water to flow into the well.

Unfortunately, well-points made with perforated pipe base and brass jackets have always suffered from the damaging effects of corrosion. Much of the difficulty comes about because of the two-metal construction. When brass and steel are placed in contact with each other and immersed in water or other fluid that will conduct electricity, a small electric current will flow between the two metals. We call this a galvanic current. Electrolytic action results and causes corrosion.

Conventional well-points could, of course, be made entirely of corrosion-resistant material if, instead of ordinary steel pipe, Everdur or stainless steel pipe were perforated and used as the structural element. However, both Everdur and stainless steel pipe are costly. Stainless steel pipe is difficult to perforate. So far, no one has produced drive points commercially with either of these materials employed as the pipe base.

All-Welded Construction

The invention of the welded well screen, fabricated of cold-drawn wire shapes, opened the way for the development of drive well-points manufactured entirely of corrosion-resistant metals. Several years' work was required to develop a means of giving the well-points adequate impact strength to resist hard driving. Engineering and experiment eventually brought the answer. Everdur well points were developed first and were followed later by stainless steel points, as we have already indicated.

Stainless steel is a very tough alloy, especially the types containing at least 18 per cent chromium and eight per cent nickel. It welds nicely to form strong joints. With the proper proportioning of the wire shapes used in their manufacture, the stainless steel drive points now available will stand an unusual amount of hard driving and abuse. The present-day product made of 18-8 (type 304) stainless steel will take

New Phone Number

Our telephone number is now **MIdway 6-2555,** to conform with the nation-wide revision in telephone exchanges. Also, our manufacturing facilities have been moved to 1670 Roblyn Avenue in St. Paul. Moving has caused some delays in shipments of screens and we apologize to those customers who have been held up on this account. Shipments are now going out on schedule.

Our office will remain at 2304 Long Avenue, St. Paul 14, until September or October.

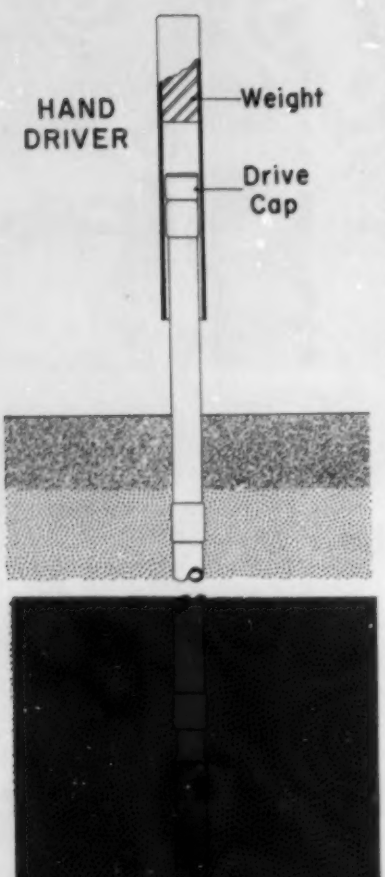


Figure 1. Simple hand driver for driving well-points to depths of 15 to 30 feet. Handles can be attached to opposite side of the driver.

much more impact than the Everdur well-point will do.

The application of the welded screen in well-points not only permits making them of a single high-quality metal but also gives them the efficiency of the larger well screens. Experience has proven that the continuous-slot well screen, with V-openings that widen inwardly, is the best on several counts. The large inlet area of this screen results in low velocity through the openings and, consequently, minimum friction loss in the screen. The V shape of the screen openings prevents clogging that might otherwise build up additional resistance to flow.

The V-shaped openings also permit removal of the finest particles of the formation, leaving the coarser particles as an envelope around the well-point as a natural gravel pack. This local development of the formation around the well-point takes place when the well is being pumped out to clean it after installing the screen to the desired depth. Continuous-slot well-points are available in a wide range of sizes of openings — from No. 6 to No. 100 slot — which permit using the right screen to fit the grading of the water-bearing sand formation.

With all these advantages, a stainless steel drive point, three feet long costs about $30 more than an ordinary well point. This extra investment by the well owner actually means economy to him in the long run. For example, a well 100 feet deep equipped with an ordinary well-point may cost $350. The cost if equipped with stainless steel well-point is $380. Suppose the well should become incrusted five years later and require

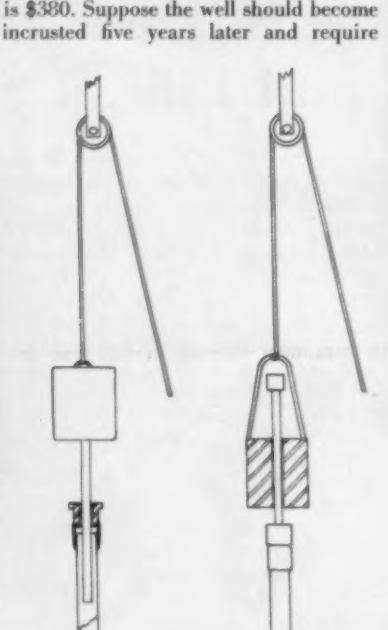


Figure 2. Heavier types of hammers used for driving well-points. These may be operated either by hand labor or by machine.

cleaning. The cost of pulling and replacing the ordinary well-point would be $100 or more. The stainless steel screen can be acid-treated in place, without pulling, for about $25. Thus, the owner saves $75, or more than twice the difference in the cost of the screen, on the first maintenance call.

To get the most from an Everdur or stainless steel well-point, it must be correctly installed. The well screen is the heart of the well. Skilled well drillers

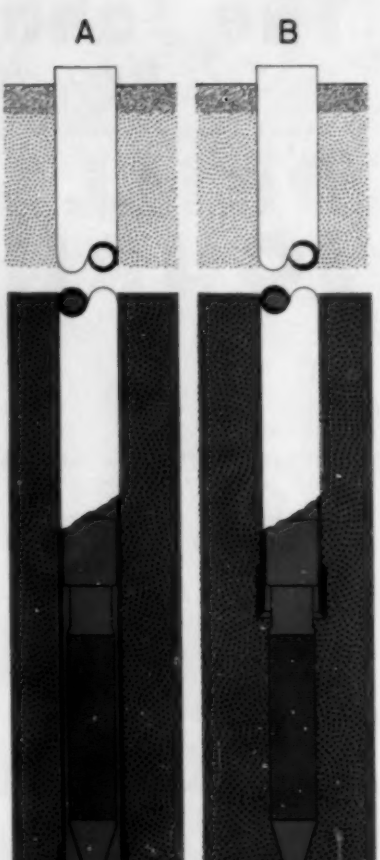


Figure 3. Drive well-points are often set in deeper wells by the pull-back method, similar to the way larger well screens are installed.

have developed, by ingenuity and experiment, practical methods of installing well-points which insure good results. We present here the details of several of these experience-tested methods for the benefit of all drillers. This is not a "do-it-yourself" article for the well owner. Its purpose is to circulate information in the drilling industry about the practical ideas that well drillers have worked out for themselves.

The Right Equipment

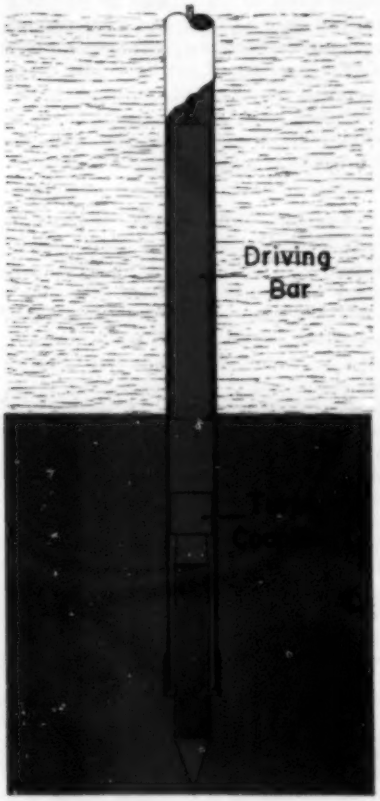
The application of sound methods of installation requires the use of the right equipment. There is no substitute for good machines and special tools, all kept in the best possible working condition. No driller can do a decent job for his customer with junk equipment and inadequate or worn-out tools.

Well-points can be driven from the

ground surface to depths of about 30 feet by hand methods, depending upon the tightness of the soil. Whether driving is to be done by hand or by machine, the first step is to bore a hole with a hand auger slightly larger than the well-point. The bored hole must be vertical and should be carried as deep as possible. The drive well-point and one or more five-foot lengths of riser pipe are assembled. Special drive couplings should be used to give the screwed joints added strength and thus prevent breaking or stripping the threads. Pipe thread compound is applied to the threads to make the joints air-tight. When ready, the well-point and riser pipe assembly is set in the bored hole. A malleable iron drive cap is screwed to the top and driving is started.

Hand driving is best done with the kinds of equipment illustrated in Figures 1 and 2. Figure 1 shows a tool similar to the type used for driving steel fence posts. It may be operated by either one or two men depending upon its weight. Driving can also be done with a heavy maul, but this is not recommended. It is difficult to deliver square, solid blows with the maul; glancing blows may break or bend the pipe. With any method of driving, the riser pipe must be held perfectly vertical.

Figure 4. A drill stem or other heavy bar may be employed to drive well-point into the sand formation below the end of the well casing.



Weight Is Important

The driving tools shown in Figure 2 may be suspended from a tripod and operated by one or more men. The driver must be hung directly over the center of the well so it will strike square blows. The weight of these tools may be anything from 75 to 300 pounds or more. The heavier driving weights are more efficient and are usually operated with a light well-drilling machine. The spudding action of a cable-tool machine is ideally suited for rapid driving with tools of these types.

To insure the threaded joints remaining tight, the riser pipe is given a slight turn with a wrench from time to time, but care should be taken not to twist the pipe severely. Twisting does not make the well-point drive any easier and may damage it. The wrench should only be used to take up slack in the threaded joints.

When the well-point has been sunk to the desired depth, the well should be cleaned out and developed. This is a most important step in completing the well. Development of the formation around the screen brings the well up to its maximum yielding ability. The desired effect is obtained by surging water in and out through the screen openings, to remove the silt and finest particles of sand from the formation. A loose plunger worked up and down below the water level inside the riser pipe will surge the well. Or, a used pump can be employed by connecting it to the riser pipe and alternately stopping and starting it to produce a surging action. Pouring water in the well to backwash it from time to time also helps to develop and stabilize the formation around the screen. When it appears that the well is fully developed, it should be pumped out to waste until it is delivering sand-free water.

As soon as the well has cleared up, it is highly important to check for sand inside the well-point. Any sand that may have settled in the bottom of the screen must be removed. To do this, lower a string of ½-inch pipe in the well and attach a hand pump to the top of it. Pour water into the well around the ½-inch pipe and operate the hand pump at the same time. As the sand is pumped out, lower the ½-inch pipe until it reaches to the bottom of the well-point. Continue pumping until the water clears up again.

Well-points are frequently installed in deeper wells by the pull-back method. The well casing is first put down to the full depth of the well by drilling, driving and bailing. A turned coupling is screwed to the top of the well-point. The well-point is then dropped down through the casing to bottom. Next, the casing is pulled back to expose the screen in the water-bearing sand. Figure 3 illustrates the steps in this method.

The drilling tools may have to be let down on top of the well-point to hold it down as the casing is pulled. Also, if heaving sand makes it difficult to clean the casing to bottom, the well should be filled with water to counteract the heave while the screen is being set. Careful measurements must be taken to make sure that the casing is pulled back the proper distance but not too far. The

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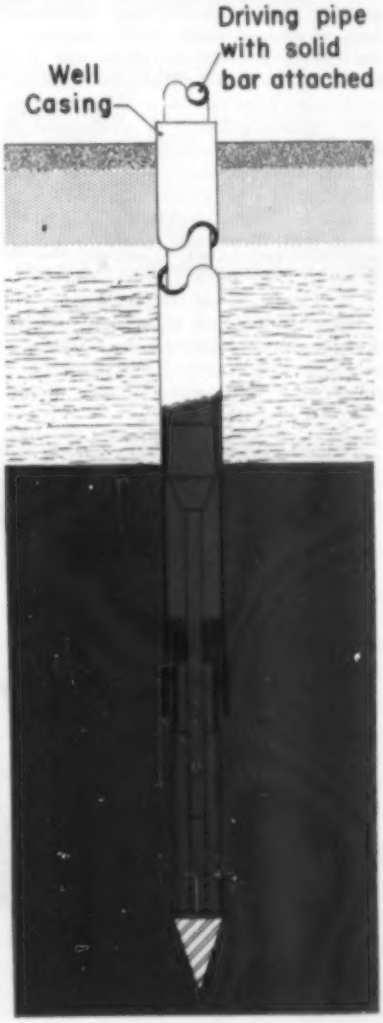
Figure 5. Driving with a small solid bar, striking directly on the point of the screen, is a good method for sinking well-point into the water bearing sand beyond the casing.



Hydrologic Aspects of Ground Water Law

Workable water laws are written only when ground and surface water hydrology is clearly understood

By THAD G. MCLAUGHLIN

In order to discuss the subject of ground water legislation with maximum competence, one would have to be trained thoroughly in both ground water hydrology and law. As the author is a ground water hydrologist with a limited knowledge of law, this article will be largely devoted to the technical features of ground water legislation.

At least a part of the difficulty in interpreting and enforcing ground water legislation is inherent in the various archaic and arbitrary legal classifications of ground water. The lawyers and the courts are not to blame for this situation, because hydrologists until recent years have not been able to evolve clear classifications. A distinguished water litigation attorney has advised the author, however, that some of the legal classifications of ground water are supported by such weighty judicial precedent that they must continue to be used, even though contradictory to fact.

Problem of Definition

Definitions taken from two judicial decisions will illustrate the problems involved. One court defined percolating water as "vagrant wandering drops moving by gravity in any and every direction along the line of least resistance." Another court stated: "the physical laws governing underground water and its subterranean progress [are] irregular and unknowable with certainty, and such water [is] changeable and uncontrollable in character [and] subject to secret and incomprehensible influences."

Ground water has been divided into many legal classes, including underground rivers, underground lakes, percolating water, diffused water, defined underground channels, and springs. The author does not know what is meant by these different classes and seriously doubts that anyone else knows either. The first two terms, underground river and underground lake, date back to the period when the subject of ground water was somewhat of a mystery, and people speculated that ground water occurred in the form of rivers and lakes just like surface water. Actually, nearly all ground water is percolating water—that is, it moves by laminar flow—whereas most surface water moves much more rapidly, by turbulent flow. Ground water is controlled largely by geology, surface water by topography, and atmospheric water by temperature and pressure. Hence, it is nearly as logical to say "underground cloud" as it is to say "underground river" or "underground lake." Even in the rare limestone and volcanic-rock terranes where ground water does move in well defined channels by turbulent flow, other factors may make the term "underground river" inapplicable.

The inaccurate legal classification of ground water is, in the author's opinion, the principal cause of the failure of many attempts to regulate ground water use. From a technical point of view, no attempt to set up different classes of ground water is justified. A single drop of water may at one time be percolating water and in a defined underground channel, may subsequently appear as diffused surface water or in a spring, or may even contribute to the base flow of a surface watercourse; it is evident, therefore, that the legal classifications of ground water are unworkable.

Irrigation well 347-feet deep, drilled by Watts and Vestal Drilling Company of Farwell, Texas.

Ground and Surface Waters

It is also problematical whether there should be a distinction between ground water and surface water. The terms ground water, surface water, and atmospheric water do not apply to permanent states of water but merely represent water at a particular stage of the hydrologic cycle. A single drop of rain falling to earth may move into a stream and become surface water. A short distance beyond, it may be lost through the stream channel to become ground water, and a short distance farther, it may return to the stream. There is a continual interchange of ground and surface water, and the base flow of nearly all perennial streams is maintained by the discharge of ground water. There does exist one fundamental

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Mr. McLaughlin is district geologist of the Ground Water Branch of the Water Resources Division of the U. S. Geological Survey, Denver, Colo. Permission to publish granted by the Director, U. S. Geological Survey.

difference between ground and surface water, however, which is important in ground water legislation: runoff in streams can be measured with some degree of accuracy, and when all the water in a stream is appropriated, the fact is obvious to everyone. The increment of the ground water supply, known as recharge, is roughly analogous to surface water runoff, but there is also the factor of storage, which is not involved in surface water under natural conditions. In many places, large quantities of ground water have been stored in underground reservoirs for periods of thousands of years. When pumpage is sizable, it brings up the question of whether the recharge alone is being withdrawn or whether the storage is being depleted. The problems faced by formulators of ground water legislation can best be illustrated by discussing situations in areas where detailed information is available.

Pump testing new 20-inch naturally-developed well at Eau Claire, Wisconsin, at 1750 gpm with 3.5 feet drawdown — a specific capacity of 500 gpm per foot drawdown. The well is 85 feet deep and is equipped with a Johnson Everdur Well Screen 35 feet long.

Low-Recharge Storage

The High Plains area has little natural recharge. This region is underlain by the Ogallala formation, a very productive aquifer. It extends from the Black Hills of South Dakota to the southern part of the Texas Panhandle and includes parts of South Dakota, Nebraska, Wyoming, Colorado, Kansas, Oklahoma, New Mexico, and Texas. The area comprises about 156,000 sq. miles (about the size of California), and the underlying aquifer is believed to have in storage about two billion acre-feet of ground water.

The region is almost everywhere surrounded by land at lower elevations. Thus, ground water moves away from the plains, and the ground water source must be the precipitation within the plains. This averages only about 20 in. a year, and only a very small percentage reaches the water table, so that the recharge is very low. It is believed to range from less than ¼ in. annually in parts of Texas and New Mexico to as much as 3 in. in part of the sand hills area of Colorado and Nebraska.

In the High Plains of Texas, farmers pump nearly 5,000,000 acre-ft. of ground water a year in an area where the annual recharge is believed to be less than 100,000 acre-ft. Furthermore, a comparable amount of natural discharge also occurs. Although the water is being mined rapidly, the supply has already lasted 20 years and may last several decades longer, enough time for the repayment of most existing investments. Meanwhile the area is enjoying a prosperity not otherwise possible.

In the central and northern High Plains, the aquifer has not been developed to any such extent, and there is the problem of how it should be devel-

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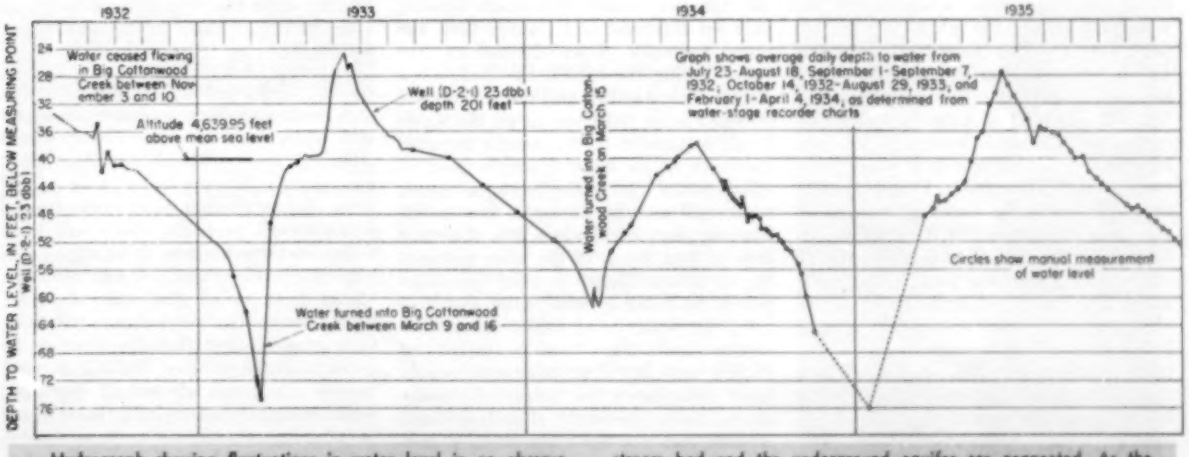
1932
1933
1934
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DEPTH TO WATER LEVEL IN FEET BELOW MEASURING POINT
Well (D-2-I) 23 dbb1
24
28
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44
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52
56
60
64
68
72
76
Water ceased flowing in Big Cottonwood Creek between November 3 and 10
Altitude 4,639.95 feet above mean sea level
Well (D-2-I) 23 dbb1 depth 201 feet
Water turned into Big Cottonwood Creek between March 9 and 16
Water turned into Big Cottonwood Creek on March 15
Graph shows average daily depth to water from July 23-August 18, September 1-September 7, 1932; October 14, 1932-August 29, 1933, and February 1-April 4, 1934, as determined from water-stage recorder charts
Circles show manual measurement of water level

Hydrograph showing fluctuations in water level in an observation well 50 feet from the bank of Big Cottonwood Creek in Utah. During periods of low flow or no flow in the stream, the water level in the well drops rapidly. After water again begins to flow in the stream, the water level in the well rises rapidly—showing that the stream bed and the underground aquifer are connected. As the stream recharges the aquifer, surface water becomes ground water. In the dry season, some of the ground water reappears in the stream channel as surface water. This example illustrates the interchange of ground and surface water discussed by the author.

Illustration, courtesy U. S. Geological Survey.

oped. It does not seem feasible to develop only the recharge and save the storage. In the first place, the recharge in any aquifer cannot be fully developed until the water levels are lowered. Then the question arises as to who is entitled to the stored water that is pumped out while the water table is being lowered. In the second place, it is difficult to take the recharge without also taking the storage. Before man diverted water and drilled wells, most aquifers were in equilibrium—that is, the discharge from an aquifer over a period of years was equal to the recharge to the aquifer. Because there is little fluctuation of the water level in the aquifer in the central and northern High Plains, hydrologists know that the aquifer is still essentially in equilibrium. In order to salvage the recharge, the discharge must also be captured. If an amount equivalent to the recharge is pumped and the discharge is not stopped, the water levels will decline, and water will be withdrawn from storage.

The Frenchman Creek area in northeastern Colorado is a region where recharge alone cannot be pumped. All recharge on one side of the ground water divide moves eastward across the state line. The amount of ground water flowing across the state line annually is equivalent to the annual recharge to the ground water reservoir. It has been determined that the underflow across the state line is on the order of 100,000 acre-ft. a year, equivalent to slightly less than 1 in. of recharge annually in the area. Suppose it were decided to pump only the recharge of 100,000 acre-ft. annually. A withdrawal of 100,000 acre-ft. of water uniformly throughout the area would lower the water table over the whole region less than ½ ft. The thickness of water-bearing materials at the state line averages about 200 ft. The withdrawal of 100,000 acre-ft. of water, if uniform, would not change the hydraulic gradient appreciably. The withdrawal would only reduce the thickness of the section through which the water is flowing at the state line from 200 ft. to 199½ ft. Consequently, the discharge would be reduced by about one part in 400. Only about 250 acre-ft. of recharge would be salvaged, and the remainder of the 100,000 acre-ft. of water would come from storage. In an aquifer of this type, it appears that there is no choice but to mine the water.

High-Recharge Storage

The storage problem is considerably different in areas where the recharge is high — for example, where large amounts of surface water are spread on the land for irrigation. In the Closed Basin in the San Luis Valley, Colo., about 300,000 acre-ft. of surface water is diverted to the land annually for irrigation. During periods of low stream flow, nearly a thousand wells have been drilled to supplement the water supply. In 1951 the stream runoff reached a record low, and wells pumped nearly 300,000 acre-ft. of ground water, resulting in an average water table decline of several feet. During the following year the available surface water supply was above normal. very little ground water was pumped, and the ample artificial recharge returned water levels to normal. This area has an ideal combination of surface and ground water use. Also the ground water reservoir serves as a nearly evaporation-free reservoir to be called upon in times of surface water shortage. It would be disadvantageous to mine the ground water in this region. If the ground water is developed only to the extent of the artificial recharge, it will last as long as that recharge does. Moreover, the natural recharge can be partly salvaged, because this water is now being dissipated by evapotranspiration, which can be reduced by lowering the water table. There are similar situations in the Arkansas and South Platte valleys, where large quantities of surface water are available for recharge.

Coordinate Uses

Surface and ground water uses should be coordinated in many areas rather than permitted to conflict. There are sections, for example, where it may be wise to abandon the use of surface water to do all irrigating by wells. In the Arkansas Valley in western Kansas, between Hartland and Garden City, the river normally flows throughout the year. During the 1930's, however, when stream flow was low and the withdrawal of water from wells was large, the water levels declined 5-10 ft., enough to cause the river to go dry. A single flood in 1941 caused the water levels to return to normal and the stream to flow again. Records show there was a loss of stream flow in that reach of the river amounting to about 75,000 acre-ft. In other words, by using ground water and lowering the water level below that of the stream bed, there was a saving of 75,000 acre-ft. that otherwise would have gone down the river. In many places where the supply of surface water is small and not too dependable, it may be well to substitute pumping in order to lower the water table and capture water by channel infiltration that would otherwise go on downstream.

A major problem to consider is whether there should be a vested right in lift. Water cannot be withdrawn from an aquifer without lowering the water level. It is impossible to pump a large number of wells in a field without causing each well to affect the water levels in the others. If there is a vested right in lift, the well owner second in time would have to pay tribute to the first, and so on down the line until the latest comer would be paying tribute to all. It seems clear, therefore, that a vested right in lift is usually impractical. There is, however, a problem of conflicting uses of water. For example, it is questionable whether an industry that can operate profitably with a lift of 500-1,000 ft. should be allowed to lower the water level excessively in an area where the farmer's economic limit of lift is only 150-200 ft. The same conflict probably would arise between large and small farm operations. Another problem in connection with lift is the maintenance of artesian flow. The San Luis Valley for example, is filled to a depth of more than a mile with sediments consisting mainly of alternating layers of clay and of sand and gravel. The layers of clay impede the upward movement of water, developing artesian pressures. Water from any of the beds of sand and gravel below about 100 ft. will rise to the surface and flow. The farmers in that area are drilling ever deeper wells to tap those flows. A number of recent wells are 1,000-2,000 ft. deep. The great cost of developing these wells is partly compensated by the fact that the water flows at the surface and there is no pumping expense. It appears that, in such situations, it may be necessary to protect the right in lift (or in lack of lift) in order that it may continue to be economically feasible to tap the deeper aquifers.

Effect on Streams

A touchy problem is what to do about well users who take water that would otherwise reach a stream on which there are water rights predating those of the wells. Before ground water codes can be administered properly, there will have to be considerable new thinking on this subject. In Colorado, for example, the courts have ruled that ground water users cannot take water that is tributary to a stream, and that the burden of proof is on the pumper. If this rule were enforced strictly, almost all pumping would cease, for nearly all ground water is tributary to a stream or is moving toward a stream. Much of it never reaches the stream but is lost by evapotranspiration on route.

The ground water along the western

(Continued on Page 15)

IMPROVE YIELD OF WELLS

(Continued from Page 3)

turned coupling provides a collar at the top of the well-point which fits rather closely in the casing. A check valve or rubber packer can be readily seated on top of the turned coupling.

When well-points are used in deeper wells in this manner, the 1¼-inch well-points are employed in two-inch wells; two-inch well-points are normally used in three-inch wells. Two-inch Everdur and stainless steel well-points are some-

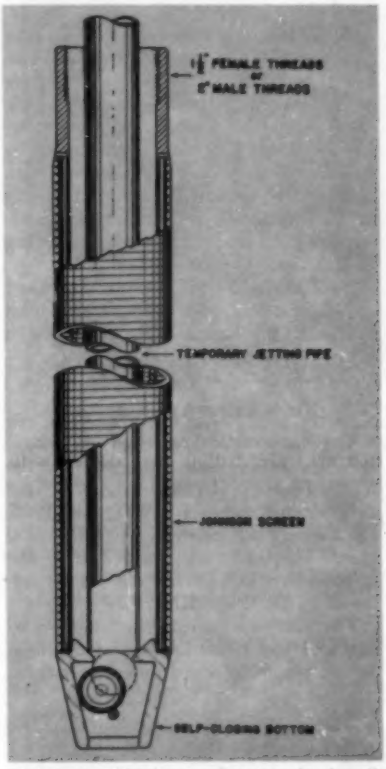


Figure 6. Everdur or Stainless Steel well-point with self-closing bottom. One-inch pipe is used for the jetting line in two-inch well-point. When jetting is stopped, the back pressure of the water bearing sand closes the bottom valve.

times utilized to advantage in four-inch wells. In such cases a four-inch lead packer is screwed to the top of the well-point in place of the turned coupling. After the pipe is pulled back, the packer is expanded inside the casing to make a sand-tight seal at the top of the screen. Some well drillers have also devised rubber packers for attachment to two-inch well-points that are to be installed in four-inch wells.

In some situations, the pull-back method cannot be used because the friction on the casing is so great that the force required to move it might pull it in two. In such cases, a drive well-point can be driven beyond the end of the casing into the formation below. The driller must know, of course, that the water-bearing sand extends deep enough below the bottom of the casing to permit installation of the well-point in this way.

The casing is carefully cleaned out to bottom so the well-point will not become sand-locked inside the pipe. If the sand tends to heave, the well is kept full of water while the screen is being set. The well-point, with a turned coupling screwed on the shank, is dropped through the casing. A driving bar, drill stem or other similar tool is let down and alternately raised and dropped to drive the well-point out the bottom of the casing, as shown in Figure 4. If drilling is being done by the hollow-rod method, the string of drill rods can be used as the driving weight. Careful measurements must be made by the driller so he will know when the screen has been driven the right distance.

Figure 5 shows another method that delivers the driving force directly on the solid point of the screen. This method is often preferred when driving relatively long well-points. A ¾-inch solid bar should be employed for driving inside 1¼-inch well-points and a 1½-inch bar should be used inside two-inch well-points. A string of pipe or a stem can be used to provide the required weight. If a lead packer is used on top of the well-point in place of the turned coupling, this method of driving must be employed since it is impossible to drive on top of the packer. As in the pull-back method, two-inch Everdur and stainless steel well-points with four-inch lead packers can be readily installed in four-inch wells.

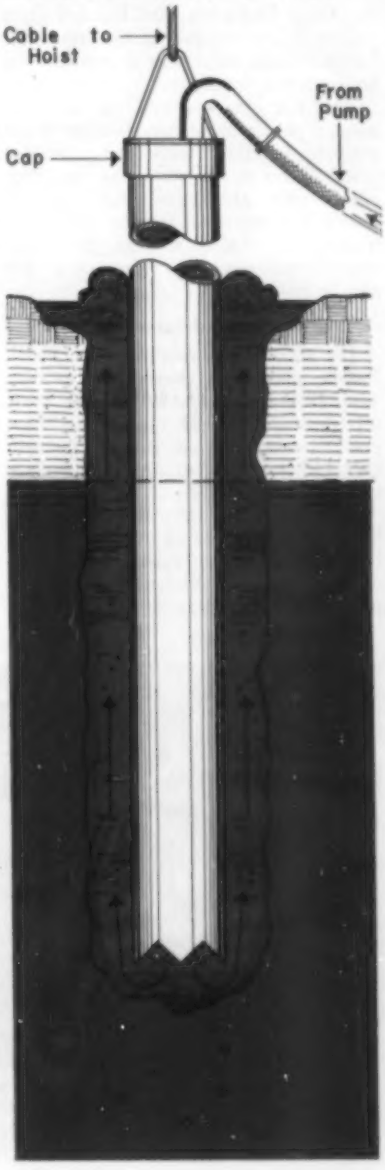
Cleaning and Developing

Regardless of the method of installing the well-points in these deeper wells, each well should be carefully developed after the screen is in place. A surge plunger, operated a few feet below water level inside the well casing, will force water in and out through the screen openings and remove silt and other finer materials from around the well screen. This is the usual method used to develop an envelope of coarser sand and gravel around the outside of the screen. This developed zone allows the water to come into the well more freely and bring the well to its maximum efficiency. It also stabilizes the formation and insures a sand-free well. Back-washing by pouring 100 gallons, or more, of clean water in the well several times during the development operation also helps to further the development work.

The fine sand brought into the well by surging and backwashing will partially or completely fill the well-point. This material can be pumped out with a used pump cylinder. The well driller furnishes this equipment as one of his valuable services to the owner. A ½-inch suction pipe long enough to reach to the bottom of the well-point should be attached to the bottom of the pump

(Continued on Page 11)

Figure 7. Method of jetting an open hole by using string of pipe with upper end capped. The well-point is dropped into place when hole is opened to the desired depth, as described in text. The hole must be kept full of water to avoid caving until well-point is in place.



Capping of the artesian wells emptying into the Fort Randall reservoir area points up South Dakota water problem

Stop Ground Water Waste

The job of sealing off artesian wells emptying into the reservoir area of the Army Engineers Fort Randall Dam project is a forerunner of measures that South Dakota must take to preserve its groundwater resources.

The 102 artesian wells in the permanent pool area of the Missouri River project, together with an estimated 5,500 others in the state, are the product of what geologists identify as the state's Lakota and Dakota sandstone formations. Lying one on the other, these formations range from 100 to 200 feet in thickness.

How Groundwater Forms

The sandstone formation in its South Dakota portion is shaped like a huge underground saucer. It reaches from the Black Hills on the west to the Sioux Falls area on the east, running beneath both Dakotas and coming to the surface at Dakota City, Neb.

Water trickling down the sides of the Black Hills, according to one theory, seeps into the exposed sandstone formation and travels underground to all parts of the state. Because the Black Hills tower above the land in the rest of the state, the water stored in the formation is artesian. Tap the strata with a well in almost any part of South Dakota where the formation is more than 700 ft. below ground surface and water will come gushing.

The countless gallons bubbling without interruption for more than a half century reportedly show signs of depleting the underground supply. In central South Dakota, the head has been slackening off about six feet per year. Wells have ceased to be artesian in other areas.

In arid South Dakota, signs of a lessening groundwater supply are a matter of serious public concern. Gov. Sigurd Anderson has appointed a groundwater and artesian well commission to study corrective measures for eventual legislative action.

Because the Fort Randall reservoir would be operating before the state would be ready to do anything about the wells, the Army Engineers were asked to plug the wells in the minimum pool.

Army Engineers are in the final phase of the work. Of the 102 wells, 21 are being plugged. They are the larger wells that contribute the bulk of the 8,000 to 10,000 gpm of well water flowing into the reservoir. It would be uneconomical to plug the others, which have flows less than five gpm. Capping of 42 additional wells above the minimum pool area will be delayed, pending possible state action.

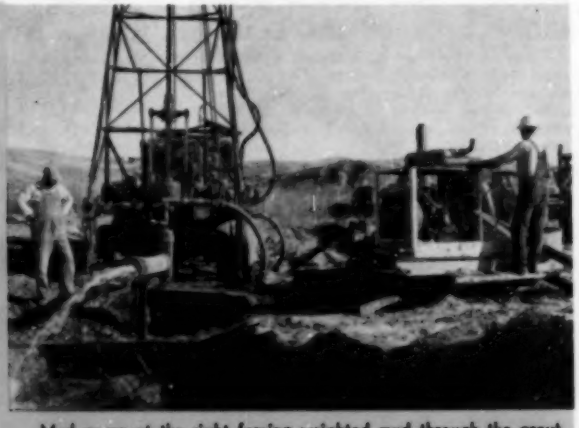
Plugging technique had to be worked out as the job progressed, said John Trantina, geologist for the Omaha Army Engineer District.

How They Are Capped

The largest and most troublesome well in the Randall area was on the White River in Lyman County. This well, drilled between 1900 and 1905, was kicking out between 600 and 1,000 gpm. The water had washed away the surrounding soil to form a bayou adjacent to the White River.

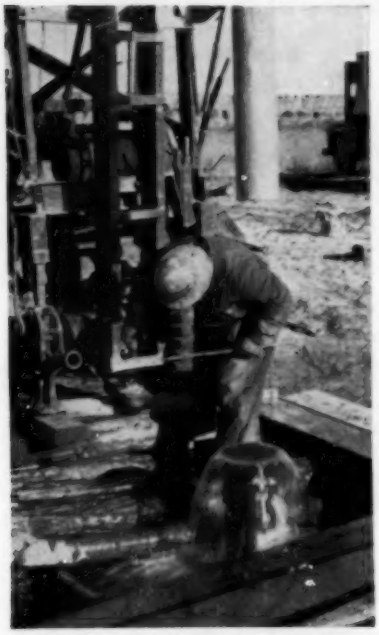
The well was beneath the water's surface and had to be located by probing. Before plugging operations could start,

Typical flowing well in South Dakota with no provision for controlling or shutting off the flow. This is one of the many wells plugged by the Army Engineers in the area that will be covered with water backed up by Fort Randall dam.



Mud pump at the right forcing weighted mud through the grout pipe first set at 420 feet. Well was partially shut in during this operation. Further grouting at 588 feet below ground was required to plug the well completely.

the 30-foot bayou had to be filled as a platform for the workmen. A three-foot casing was set in the well. Plugging



View of the well described showing artesian flow of 200 to 300 gpm coming out of 8-inch casing that had been set to a depth of a little over 51 feet. At least 700 gpm escaped outside the 8-inch pipe.

was carried out with mud scientifically selected for the conditions.

Workmen first pumped in bentonite, which swells on contact with water. The object was that this mud would expand and seal off any voids or cracks in the sandstone formation through which the water might be diverted to spout up again.

Next sent down was mud composed of barium sulphate, a very heavy mineral, whose weight would offset the water's pressure. Finally, the casing was plugged with cement. In all, the job required 75 tons of material.

The tremendous force of water generated by some of the wells was demonstrated in no uncertain terms at one location. Workmen had set up their drill rig on a concrete watering trough and sunk a casing in the well. The water had been buoying up the concrete tank. With the water diverted, both tank and drill disappeared into the ground. Only the tip of the rig's derrick was visible when workmen came on the job next morning.

Cost of plugging operations runs from $300 to $8,000 per well.

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(Editor's note: We add the following to the article from Engineering News-Record to give more details of the sealing operation.)

The accompanying diagram shows, in a simplified manner, how the well described in this article was finally plugged. After first placing the large diameter casing over the spot where water was bubbling up out of the sand, an attempt was made to locate the old well bore by probing with a jetting pipe. The jetting pipe was stopped at a depth of six feet by debris and coarse gravel.

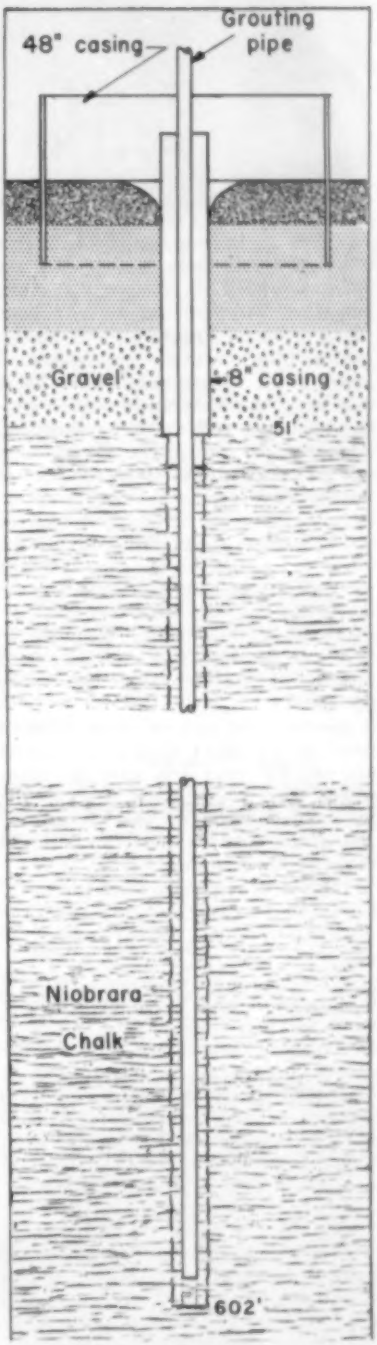
An eight-inch pipe was then driven down inside the large casing to the Niobrara chalk. This bedrock formation was encountered at 51 feet below the surface. After seating the pipe in the bedrock, a flow of 200 gpm came up through it. Perhaps as much as 1,000 gpm of water was flowing out of the chalk formation into the gravel outside the eight-inch casing.

Next, a string of two-inch grouting pipe was lowered inside the eight-inch casing. Upon striking an obstruction at 170 feet, it was pulled out. A 3⅞-inch rock bit was then used to open the hole at 170 feet. The grout pipe was again lowered and went down readily to 420 feet. Grouting operations were started at this level. However, after pumping more than 27 tons of grout and weighted mud into the well, neither grout return nor shut-off of the artesian flow occurred. Apparently, the Niobrara chalk contained large fractures which allowed the grout to escape into the coarse gravel lying on top of it.

The grout pipe was then lowered to the bottom of the well, found to be at 602 feet. Fourteen tons of weighted mud were pumped in, half of it at the 588-foot level and the remainder at the 58-foot level. Pump trouble caused some delay and the grout pipe was broken while pulling it. The well continued to flow at about 200 gpm.

The hole was then reamed with a six-inch rock bit. No casing or fragments of pipe were encountered, although local residents offered the opinion that the well had been cased originally.

A three-inch grout pipe was lowered to a depth of 514 feet. Five tons of bentonite and 20 tons of weighted mud were prepared. The bentonite was pumped in first and followed by the heavy mud. When half the mud had been used, the flow of the well appeared shut off. Pressure started to build up in the line and as mud-pumping continued the pipe had to be raised a total of 220 feet to prevent excessive pressure. Eight tons of cement grout were then pumped in on top of the mud.



After more than five hours of nearly continuous pumping, grout returned through the eight-inch casing to the surface. The grout pipe was pulled, thus completing a difficult sealing job.

Awhile back I was at a big dinner where they had some high-powered speakers who were giving us what was supposed to be the low-down on our national problems straight from th' horse's mouth. It was a downright interesting meeting, but I came away feeling like I was living in a dizzy world where everything was due to blow up, or shoot up, or fold up, or burn up, or dry up 'most any day. If the rate of speed-up is as fast as they say it's goin' to be in th' next ten years — if this pace gets as much faster as it has during th' last ten years — I wonder how us human beings are going to keep up to it. But, I guess that's what we said ten years ago, too, so we might just as well go on living th' best way we know how and leave it to the good Lord as to how it comes out in the end.

Anyway, that ain't th' thing I had in mind to say about what these experts told us. Th' man who gave the main speech was telling about how in this present-day world of ours everything was a race between rival forces to get th' most power in their hands.

There's th' democracies against th' commies; the eastern world against the western world; one country against the other — each one putting a wall o' power around its own set-up. Not with th' thought of using it, but more to scare the other fellow away. And the outfit that is going to come out on top is the one that's got th' resources. Not so much what's made up ready to go — because that gets obsolete awful fast — but just like the old-time general said, it's who can get "th' mostest there th' fustest."

Everything But Water

Then this speaker went on and said what all of this meant to him — skilled manpower, lots o' food growing capacity, iron, coal, alloys, aluminum, copper, electric power, factories, railroads, trucks, highways. And so on and on he listed jest about ev'rything you could think of — except what is th' most important of all, *water!*

Doggone it all, it seems sometimes that everybody just takes water for granted — and that goes for us people who are right in th' business, too. We all get so used to having water whenever and wherever we want it that we never give it a good, long thought unless something special happens like when th' shipwrecked sailor in th' poem ran out of drinkin' water he yelled, "Water, water everywhere, but not a drop to drink!"

Do you know something — it ain't any laughing matter! Water is our most precious natural resource, but we treat it like it wasn't important at all — like it was something we'll always have plenty of, no matter what happens. We don't pay near as much attention to it as we do to th' stock market going up an' down. That's a dangerous viewpoint for us to take as a nation — and a very foolish one for us to take as well drillers.

Th' truth is that water is a resource that keeps all th' wheels of our life turning. It's more important than oil or coal or iron or copper or aluminum or any of these other things. You can import and stockpile metals, but you can't produce them without water. And the only way you can stockpile water is by protecting th' storage areas we've got, especially th' underground basins which are bigger and safer and more economical than all of those on th' surface of the ground.

Inadequate Water Supplies

If you don't think this problem of water supply is a hot one right now, just take a look around. For th' country as a whole, I read in a recent top grade magazine that only a little over half of this country's public water supplies are considered adequate right now. There is probably not one large-size irrigation area that has all th' water it wants. There's a never-ending struggle among th' states in the southwest part of the country, for more water. Industry is growing fast and its demand for water is growing faster. I hear tell of a river in one of our eastern industrial areas where somebody figured out that all of th' water in th' river was used on an average of about three times, and its temperature went up something like 30 degrees, between th' first industrial plant upstream an' the last one down the line along the river's banks.

They say it takes close to 100 pounds of water to process a can o' vegetables, ten gallons for a gallon o' gas, over two tons to make a ton of cement, and 200 tons per ton of finished steel—think of it!

Most industries are taking a good, long second look at water supply before they expand in any location. More an' more of them are using our great supply of ground water and are picking new locations, in lots of cases, on the basis of th' supply o' ground water. That means more and more good business for well drillers if — and a great big IF it may be, too — *if* all of us in th' business are smart. If we play it th' dumb way we can spoil a good thing. Here are some of th' things I mean.

Important Questions

How many of us are doing everything we can to protect th' ground water from pollution? Are we using all th' care we should to keep bad waters from spoiling our good waters? I know of a place where one good water formation has gone up something like 100 parts per million in hardness from what it used to be, just because so many wells that went into it didn't carefully case off th' hard water above it. There's some industrial uses where th' hardness don't make so much difference, but in others it's important. So I'll bet there's been many thousands of feet of big wells that didn't get drilled in this area because th' water got poorer.

How many of us are keeping up-to-date so we measure a water supply by how much water we can safely get out of it year after year rather than how many gpm we can get out of it on a pumping test?

How many of us are real careful to put in th' kind of well that will do th' job in the long run, in each case instead of just what is easiest for us to sell or to drill? It makes a difference with the owner who pays all of th' bills, for original cost and for maintenance. He finds out what his total cost is for the water and makes his plans accordingly.

How many of us scream every time some government agency makes a law or regulation to conserve or protect our water supply, but we don't do anything to see that such laws or regulations aren't necessary?

How many of us want to drill all th' wells we can and get everybody we can to using well water, but aren't willing to use good judgment and cut down on drillin' too many before pullin' out more water in one small area than it will stand without spoiling it for everybody?

In one sentence — how good a job are we doing of protecting th' future of our own business? The answer to this question is going to tell us how good th' well drilling business is going to be in the future and how much regulation we're going to work under. For my part, I aim to do all I can to make well drilling a better business with th' least possible amount of government regulation. How about you?

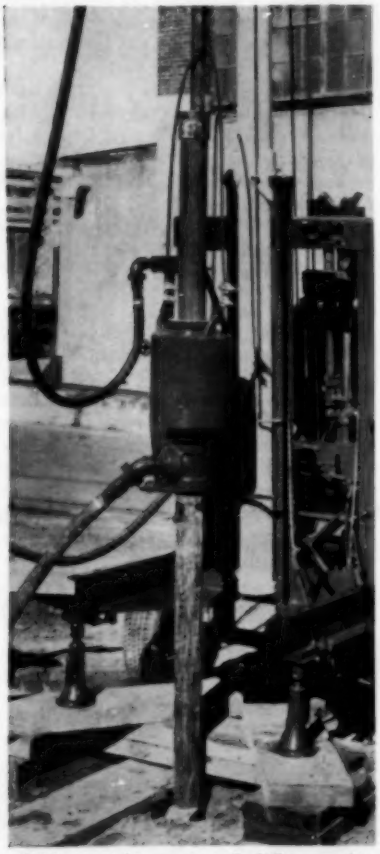
Yer ol' friend,

Tom

IMPROVE YIELD OF WELLS

(Continued from Page 7)

cylinder. If water is coming into the well freely through the screen, all of the sand can be pumped out without lowering the water level too much. However, if the water level does drop appreciably as the well is being cleaned out, additional water should be poured in at the top of the well casing. After the sand has been removed from inside the well-



Driving weight on a small drilling machine designed to drive casing for small diameter wells may also be used to drive well points. Shown here is the latest model I-W Bucyrus-Erie machine driving 3-inch pipe in a well being drilled by the jetting method.

point, additional development work should be done to be sure that the well is sand-free. If more sand comes in, the screen will have to be cleaned a second or third time. It is highly important that the well screen be completely clean throughout its full length before the well is put in service.

Jetting Methods

A Johnson well-point with self-closing bottom, illustrated in Figure 6, is designed to be washed down in sand or other loose formations. A temporary jetting pipe is used to deliver the jetting stream at full force through the self-closing bottom. Half-inch standard pipe should be used for the jetting line, if 1¼-inch well-points are being used; one-inch standard pipe is best for the jetting line if two-inch well-points are being used.

The pump needed for jetting well-points into place should have a capacity of about 100 gpm at 50 psi pressure. Under favorable conditions, a smaller pump may work all right, but it is always a good idea to have plenty of pump capacity.

For shallow wells 20 to 40 feet deep the well-point and riser pipe are jetted down as a unit. A section of riser pipe 10 to 20 feet long is first coupled to the jet well-point. The auxiliary jetting pipe is then placed inside the riser pipe and well-point, so that the bottom of the jetting pipe rests on the self-closing valve. The discharge side of the pump is connected to the jetting pipe by a suitable length of pressure hose. The hose should be at least one-inch diameter. A valve should be placed in the line from the pump discharge. All connections should be made up tight.

To start the jetting operation, dig a hole about a foot deep, set the well-point and pipe assembly vertically in the hole and partially open the valve on the discharge of the pump. As earth is washed out below it, the well-point will sink slowly. Up and down movement of the whole assembly will speed up penetration. As the jetting is continued, increase the flow of water by opening the pump valve.

If the jetting operation has to be stopped to put on an additional length of riser pipe to permit sinking the screen deeper, the hole around the riser pipe must be kept full of water until jetting is resumed. Shut off the flow of water through the jetting pipe before attempting to lift it out of the well-point. Keeping the hole full of water will prevent caving, while extra sections of riser pipe and jetting pipe are being connected.

If it is desired to sand pack the well-point in the hole, the volume of water should be cut down to reduce the velocity of the return flow. Coarse sand should then be shoveled into the hole around the riser pipe. This sand will fall to the bottom of the jetted hole around the well-point while the slow return flow keeps the hole open.

Another method of jetting that is employed for well-point installation is illustrated in Figure 7. A string of pipe is provided with a tight cap at the top and roughly cut teeth at the bottom. The pump delivers the jetting stream through a suitable connection in the cap. The hole is washed through the soil as the stream issues from the bottom of the pipe. If tight layers of silt and clay are encountered, the pipe is turned back and forth to cause the teeth to break up the harder material.

When the hole has been opened to the desired depth, the well-point and the riser pipe may be dropped down alongside the jetting pipe. Or, the cap may be taken off and the well-point and riser pipe assembly dropped down through the jetting pipe. The jetting pipe is then pulled out of the hole.

A third scheme is to utilize the jetting pipe as the permanent well casing. In this case, the well-point with suitable lead packer attached is dropped to the bottom through the pipe. The pipe is then pulled back the right distance to expose the screen in the water-bearing formation.

Cleaning and developing operations for jetted wells are done by the methods already described for other kinds of wells. Usually they can be quickly cleaned up because some of the silt and fine sand is removed by the jetting operation itself.

Summary

Well drillers who use the general features of the proven methods we have described also vary them in detail to meet special conditions. Since no two wells are hardly ever the same, there is plenty of opportunity for the driller to work out and apply ingenious ideas. The skill of the driller is demonstrated by his ability to fit basic, experience-tested methods to the geological conditions on each job so that he produces the best possible well for his customer.

"Here's a lifetime of 'Do it yourself'."

ASSOCIATION NEWS

This section is devoted to the exclusive use of water well drillers' associations, both state and local. Notices, announcements, changes of officers and other items should be sent to The Editor, Johnson National Drillers' Journal, 2504 Long Ave., St. Paul 14, Minnesota.

Missouri

A total of 170 persons registered attendance at the 19th annual convention of the Missouri Water Well Drillers Association. The meeting was held at Jefferson City on April 18 and 19. More than 100 drillers attended, and 28 firms exhibited water well supplies and equipment. This was one of the best conventions the Association has had.

The program included talks and discussions on cementing casing for water wells, loans for financing farm wells, and the development of submergible pumps. Geologist John Grohskopf reported on results of acidizing water wells in Missouri.

At the annual business meeting, the following officers were elected for the year: Frank Weldon of Cape Girardeau, president; D. T. Carroll of Swedeborg, vice president; W. B. Russell of Bolivar, secretary-treasurer. The Association asked Dale L. Fuller of the Missouri Geological Survey to serve for another year as service secretary.

Montana

The Montana Water Well Drillers Association held an interesting convention in Miles City on April 18 and 19. An enthusiastic group of drillers attended.

The program included discussions of reverse circulation drilling, the use and installation of well screens in sand and gravel formations, and the ground water situation in Montana. The drilling contractor members who were present felt that it was a most worthwhile meeting.

Carl F. Hollensteiner of Dillon was re-elected president for the year. R. A. Simpson of Malta was elected vice president; Bert Van Dyken of Bozeman was re-elected secretary-treasurer.

The members present voted to hold the 1956 meeting the first week in March. The place is to be selected later.

Washington

The directors of the Washington State Well Drillers Association met at Olympia on March 19. After discussing various points of view on the rules and regulations relating to sanitary construction of wells, President Harold Meyer appointed a committee of drillers living in Seattle to meet with representatives of the State Department of Health and discuss the Association's suggestions. A committee was also appointed to study the lien law and present suggestions to legislators for changes in the law which would make it more applicable to drilling contractors.

The next regional meeting will be held in Ephrata on July 16. The annual meeting and convention will be held in Seattle on November 4 and 5. The cooperation of all the well drillers in the state is requested to make this year's convention the best ever.

Idaho

The 1955 convention of the Idaho Drillers Association will be held at Shore Lodge, at McCall, on June 27, 28 and 29. Clifford E. Hosack of Nampa is convention chairman and is organizing all details of the meeting. The attractive location for the meeting and the program being arranged should draw a large crowd for this year's convention.

The program includes discussions on the use of well screens and on the chemical treatment of screened wells to be led by G. F. Briggs of Edward E. Johnson, Inc. John Banister of Halliburton Oil Well Cementing Company will talk on water-well cementing.

Wisconsin

The 27th annual meeting of Wisconsin Well Drillers' Inc. was held in Milwaukee, March 31 to April 2. Record attendance and a record display of equipment made this the most successful convention of the organization. Cooperation of the Wisconsin manufacturers' and jobbers' group was appreciated by the well drillers.

The well drillers recommended to the State that abandoned wells in suburban areas and on highway rights-of-way be properly plugged. They also asked that the district attorneys of the various counties be empowered to revoke drilling permits, under the provisions of the well code, rather than the State Board of Health.

Officers elected for the year are: Emil Goecks of Milwaukee, president; Malcolm Veitch of Seymour, first vice-president; Harvey Kriegel of Tigerton, second vice-president; Myron Acker of Milwaukee, treasurer. R. H. Nienow, an attorney at Morrill, continues as secretary-counsel. The 1956 convention will be held late in March and again in Milwaukee.

Michigan

The attendance and displays of equipment and materials at the 26th annual meeting of the Michigan Well Drillers Association broke every record for state drillers association meetings. More than 340 drillers registered attendance at the convention on April 28 and 29 at Lansing. In addition, some 90 ladies and 151 representatives of manufacturers and jobbers attended. Coopera-

Some of the drilling machines exhibited at the 26th annual convention of the Michigan Well Drillers' Association held April 28 and 29 in Lansing.

tion and teamwork by many hard-working members of the Association provided excellent facilities for exhibitors and efficient handling of every detail of the convention.

Practical talks on a variety of subjects made up a part of the program. In addition, working demonstrations of several kinds of equipment and of useful job techniques added greatly to the educational value of the meeting.

At the business meeting, Karl Geiger of Belding was re-elected president. O. O. Corsaut of Oak Park was elected first vice-president; Theron Brewer of Parma, second vice-president; and James Price of Clarkston, secretary-treasurer. The board of directors includes one representative from each of the 13 local drillers' groups in the state.

COLORADO

The semi-annual business session of the Colorado Water Well Contractors Association will be held on June 25 at the Stanley Hotel at Estes Park, Colorado. The business session is open to drilling contractors who are members of the Colorado Association and to drilling contractors in the neighboring states. No arrangements have been made for participation of jobbers and manufacturers in this meeting.

The registration will start Friday, June 24, at 4:00 P.M. The week-end visit to Estes Park will be most enjoyable, and a number of important matters will be decided at the business meeting. It is hoped that every member of the Association will attend.

In answer to the Association's request, the State has ruled that drilling machines and drillers' service trucks are "special mobile equipment." As "SME," the license fee is $2.50 per ton, only. The executive secretary reports that 231 drillers are now licensed in Colorado for 1955.

MARYLAND

As a result of the coordinated effort of the members of the Maryland Water Well Association, the legislature has voted that drilling contractors, doing work for a property owner, will have mechanics' lien rights. This protection for drilling contractors was needed and was one of the primary objectives of the Association this year.

The next meeting of the Association will be held on June 25. It will include a business session and a program of entertainment. The place of the meeting and other details can be secured from the secretary, Dorsey E. West, 621 Walker Street, Aberdeen.

TEXAS

July 28, 29 and 30 are the dates of the Southwestern Water Well Exposition being sponsored by the Texas Water Well Drilling Contractors Association. The meeting will be held on the campus of the University of Houston at Houston. Facilities for the exhibits, the program, and housing of those attending have been made available by the University.

A full program of discussions and varied entertainment for all has been arranged. Used well drilling equipment offered for sale will be auctioned on the last day as a unique feature of the meeting. L. E. Fuller, P. O. Box 3057, Houston 1, is convention chairman. A Texas-size crowd is expected.

MINNESOTA

The excellent program and exhibits attracted 133 drilling contractors to the 33rd annual convention of the Minnesota Water Well Contractors' Association in Minneapolis, March 24-26. In addition, 106 manufacturer and jobber representatives and many wives and guests also attended.

Reports on the life, health and accident insurance plans and the panel discussion on well problems were the highlights of the program. State legislation affecting drillers was also discussed at length.

At the business meeting, the following officers were elected: T. T. Renner of St. Louis Park, president; Herbert Bemis of Waterville, vice president; Al Zuercher of St. Paul, secretary. Norm Ovrom continues to serve the Association as executive secretary.

What's A Child Worth?
What's your answer? Suppose it's your child. How often have you said (or heard friends say), "I wouldn't take a million for that kid!"? And then discover a week later, that neither you nor your friends, were willing to put out just a few extra dollars to get needed school facilities for that same child!
Doesn't it surprise you to find that the value of a child can vary from priceless to less than a few dollars in a matter of days? Well, not really, because it actually doesn't. It's just that oftentimes we tend to forget that our children and their futures are pretty closely tied to the kind and quality of the education we can give them. Their future, and thus the future of our country, depends on your support. So it's really up to you to see to it that the children of your community get the education they deserve. In the long run it costs less.
Send today for free booklet, "How Can Citizens Help Their Schools?". Just write to The National Citizens Commission for the Public Schools, 2 West 45th Street, New York 36, N.Y. Why not do it now!
BETTER SCHOOLS BUILD BETTER COMMUNITIES

ADVERTISEMENTS

We will insert advertisements for drilling equipment wanted or for sale, help or work wanted, etc., for our readers, free of charge. Advertisements must be brief, and we cannot assume responsibility for them, but will be glad to put parties in touch with each other by this means and suggest that they investigate any offers or inquiries carefully for themselves.

FOR SALE: Model 21-W Bucyrus-Erie drilling machine mounted on Ford truck. No tools. O. E. Lewis, Darlington, Indiana.

FOR SALE: Bucyrus-Armstrong 22W drill with casing reel, clutch, sand reel, spooling device, derrick raiser, good V6 International power unit; mounted on good 4x6 GMC truck. Priced right. Glen E. Clark, Fredericktown, Missouri. Phone 581.

FOR SALE: Howell 60, all steel, drilling machine with cable; mounted on 4-wheel trailer with hard rubber tires. Good shape. Price $900. Art Vinson, Fort Dodge, Iowa.

FOR SALE: Stone 31 drilling machine with all tools; mounted on truck. In good condition and now drilling in one of toughest drilling areas. Selling because of health. Box LRR c/o Edward E. Johnson, Inc., 2304 Long Ave., St. Paul 14, Minnesota.

FOR SALE: Sullivan 200 rotary on 4x6 GMC truck, with 520′ drill pipe and all accessories; 3″ to 8″ fish-tail bits; 4″ to 8″ rock bits. With or without 800-gal. tank truck. Price, complete, $5,000. Elmer Crain, Boyne City, Michigan.

FOR SALE: Used 4″ x 24′ stem 2½x3½-7 thread, needs machining; 8″ bit and set of jars 2½x3½-7 thread; 4″ x 20′ stem 2¼x3¼-7 thread and set of jars. Two Harris air pumps, 2½″ and 4″. Please make offer. A. H. Miller, Ellensburg, Washington.

FOR SALE: Star 40 drilling machine with LeRoi engine; mounted on 1931 Model A Ford in good condition; 375 ft. ⅝″ drill line; 350 ft. ⅜″ sand line. Price $1,000. Robert T. Milton, Trevor, Wisconsin.

WANTED: Water well driller to operate either cable tool or rotary machine. Must be sober and capable of taking full responsibility. Herschel Mourning, Colchester, Illinois.

FOR SALE: No. 50 Keystone drilling machine, all steel, 1941 model. In good shape. Price, less tools and truck, $2,000. Columbia Pump and Well Co., 11018 Kemp Mill Road, Silver Spring, Maryland.

FOR SALE: Sparta machine, wood frame, rubber tires, 4-cyl. Dodge engine; 350′ new ⅝″ drill cable, 350′ of ⅜″ sand line. Three stems, 3 sets drilling jars, 8 bits, 2 bailers and other tools. Price $500. Mrs. Chas. Dunst, Route 1, Coleman, Wisconsin.

FOR SALE: No. 240 Star drill on 1941 Chevrolet truck, with 800′ drill cable and sand line. All necessary tools for 4″ wells. All in A-1 condition. Machine now working. Price $2,500. Rayburn and Martin, 121 West Sumner, Indianapolis, Indiana. (Phone GA 5497 or BL 0133).

WANTED: Driller who is familiar with setting Johnson screens and developing screened wells. Also, driller for deeper rock wells. Douglas Holaem, Beloit, Wisconsin.

FOR SALE: One 12-inch bit, almost new, joint 2¾ x 3¾ API: 4-inch square; 800 pounds. John Hamilton, Ellsworth, Wisconsin.

WANT TO BUY: Good used drilling machine complete with tools for 4-inch and 6-inch wells. L. F. Coleman, Wheeling, Missouri.

FOR SALE: Gaso, dual, reciprocating 4½″ x 6″ power pump. Good as new. Price $300. William Myers, 20 Jackson Street, Hayward, California.

FOR SALE: Keystone drilling machine, 60′ derrick, cog hoist; International engine, belt drive; number of tools. Rig will drill 3,000 feet. Price $3,000. W. F. Shetler, R.F.D. 1, Navarre, Ohio. Phone 5711.

FOR SALE: Star 240 mounted on Army 4 x 4; shock absorber on mast; level-wind device; 450′ new ⅝″ drill line; 400′ of ¾″ sand line; 4″ tools with jars; one 6″ bit. Truck has winch and new motor, all in A-1 shape. Price $3,800. Raymond E. Aul, R.R. No. 6, Muncie, Indiana. (Phone: Yorktown 857).

FOR SALE: 21 W Bucyrus-Erie drilling machine, mounted on 1939 International truck. Truck in good shape. Cable and tools available at extra cost. L. J. Becker, Clayton, Wisconsin. Phone: 22-8.

FOR SALE: No. 42 Cyclone drilling machine mounted on 2½-ton, GMC, cab-over-engine truck; 700 feet new ⅝″ drilling line and 700 feet ⅜″ sand-line. Also #40 Cyclone drilling machine mounted on 1½-ton, Ford, cab-over-engine truck. J. N. Cauffiel, 29093 List Street, Farmington, Michigan. Phone: 2405.

FOR SALE: Mayhew Model 1000 rotary; 4½x5 mud pump; mounted on 4-wheel drive Ford truck, with 2⅞″ drill pipe and tools. Has a winch on truck. $6500. Gilbert Zechman, Rt. 3, Middleburg, Penna.

FOR SALE: 55 Star, complete with truck, welder and tools for 5″ to 10″ wells; Joy diamond core drill with pump and winch, air-operated; 55 Royal Bean triplex pump, 50 g.p.m., 500 lb., continuous duty. G. E. Foster, 827 Broadway, Sonoma, Calif.

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W. M. Bellenbach.....Business Manager

G. F. Briggs.....Editor

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WANT TO BUY: From 250 to 350 feet 2⅞″ or 2⅞″ drill pipe in 10½′ joints with exploration or upset tool joints. Give full information on condition and price. Cleo Anderson, Selden, Kansas.

WANT TO TRADE: All-steel Keystone drill in good condition, with 6″ tools and lines, mounted on 3-ton 10-wheel truck. Want No. 6 Ideco or No. 35 Cyclone drill. Photographs and description on request. E. L. Graves, Box 225, Sylacauga, Alabama. (Phone 2-4213).

FOR SALE: No. 71 Star drill, four months old, mounted on 1946 Dodge truck. New tools, fully equipped. E. L. Beck, 7631 Lowell, Overland Park, Kansas, (Phone Niagara 2310).

FOR SALE: Complete shop-built rotary drill, trailer mounted, in first-class condition. Has 32′ steel mast; practically new pumps and new water tank. Equipped with 2⅞″ drill pipe with tool joints, bits from 5″ to 30″, all sizes bailers. Now operating but selling because of health. Price $4,000. S. J. Catlett, 2408 Main, Woodward, Oklahoma. (Phone 797J).

FOR SALE: Two No. 71 speed Star drills, one No. 72 and one No. 83 Star drill with or without tools. Complete rotary attachment and 1,500′ drill pipe for No. 72 and No. 83 machines. Jackson-Markus Supply Co., 3612 East 26th St., Los Angeles, California.

FOR SALE: Cyclone drilling machine, all steel, converted to wire line with shock absorber in mast; mounted on 2-ton 1947 Diamond T truck; new International Harvester engine. Excellent condition. Price $1,500. Albert R. Minor, P. O. Box 2119, Columbus, Ohio. (Phone Klondike 3711).

FOR SALE: No. 40 Keystone drill, all steel, with 6 cyl. Ford engine; transmission and V-belt drive; telescoping mast; mounted on 1½-ton 1944 Ford truck. Can be made into excellent machine with some repairs. Price $1,000. Albert R. Minor, P. O. Box 2119, Columbus, Ohio. (Phone Klondike 3711).

FOR SALE: Complete well drilling business. Includes 1953 Model 22-W drill on good 2-ton 1950 Chevrolet truck; trailer; tools, tool boxes, bailers and lots of bits. Everything for drilling and pump business. Good location. Selling due to health. Bob Evans, Box 701, Sidney, Montana.

FOR SALE: New Peerless 3 x 4 x 12 irrigation pump with Waukesha XAHU gasoline engine and accessories; 3″ Crane valve and companion flanges; skid-mounted. Pump rated 650 gpm at 80 psi; engine 40 bhp max. weight about 1,200 lbs. Price $1,000, f.o.b. Hartford, Connecticut. Olds & Whipple, Inc., 168 State Street, Hartford, Connecticut.

FOR SALE: New Rex 10M contractor's pump, with Wisconsin AEH engine, mounted on two-wheel truck. No hoses. Weight about 370 lbs. Price $250 f.o.b. Hartford, Connecticut. Olds & Whipple, Inc., 168 State Street, Hartford.

WANT TO BUY: Failing 1500 rotary dirll with high derrick and 500 feet 2⅞″ drill rod. Also want B-E 20W or 55 Star cable tool drill. Elmer Crain, Boyne City, Michigan.

FOR SALE: Drilling business including three cable tool machines, with tools, mounted on trucks. Four arc and two acetylene welders; service trucks; home-made house trailer. Large inventory supplies. Gross $20,000 to $35,000 yearly. Price, $15,000 cash. Write for details. Gust R. Lagerquist, Westby, Montana.

WANT TO BUY: Used rotary drill with 5 x 6 or larger pump. Hedges Drilling Co., R. F. D. 6, Lincoln, Nebraska.

An 8-inch Johnson Everdur Screen being set in a well for the Pinehurst Water District, Snohomish County, Washington. Upon completion, the well was put in service pumping 350 gpm. C. E. Miller of Everett is the drilling contractor.

FOR SALE: Sullivan rotary, 2,000′ capacity slim hole or 500′ large hole, with 6 x 6 Wheatley pump; truck mounted; price $8,250. Mayhew 1000 on 1949 GMC truck, $5,750. Failing 1500, double drum, 4½ x 6 pump on 1949 International truck. Two-stage 5″ turbine pump, 60′ settings, two years old, $250. Fred E. Butler, Box 481, Pueblo, Colorado.

FOR SALE: Super-H Fort Worth spudder, 2,500′ capacity, mounted on semi-trailer; has Ford V-8 engine; two 40′ shear poles and crown block. Outfit includes stems, bailers, 5″ to 15″ bits, wrenches and other tools; 900′ new drill line and 1,200′ sand line. Price $5,000; write for terms. F. W. Kroeger, 2026 So. 1322nd St., Seattle, Washington.

WANT TO BUY: All sizes bits, stems, wrenches, drive heads and clamps. Want API tool joints 2¼ x 3¼ and larger. Must be in good condition. Send full discriptions and prices. Hydromatics Corporation, Milan, Illinois.

FOR SALE: Failing rotary, Model 1000, with Gardner-Denver 4½ x 5 pump and 500′ N drill rod; hand tools and bits. Vacuum-lift water tank, 700 gal. Drill and tank mounted on Fabco Fords. Equipment now operating. Price, $7,200 cash. Also Gardner-Denver 4 x 5 pump, completely rebuilt, for $650. Owner retiring because of age. Ed Maher, 301 Church St., Andalusia, Alabama. (Phone 89).

FOR SALE: Bucyrus 24-W drilling machine, 1945 Model, V-belt drive, mounted on semi-trailer with 7.50 duals and vacuum brakes. Two-ton 1950 Chevrolet truck, cab-over-engine; tools; 1,100′ of ¾″ drill line and ⅞″ sand line; water tank; hand tools; 200 amp. welding machine built into drill. A & B Drilling Co., Scobey, Montna.

FOR SALE: Cable-tool machine, all steel, with 36′ derrick and power hoist; B-E cushion and crown sheave; ¾″ drill line and ⅞″ sand line included. Mounted on 1942 Ford truck. Ready to work. Price $1,200. Howard E. Nelson, LaCrescent, Minnesota.

HYDROLOGIC ASPECTS

(Continued from Page 6)

edge of the High Plains in Colorado is moving toward Big Sandy Creek, but it is doubtful if more than a few gallons in a thousand ever reach it. Much of the water is consumed by relatively useless vegetation. To protect the few gallons of eventual surface water the remainder would have to go to waste.

In the Frenchman Creek area of Colorado and Nebraska, it has been found that the development of about 100,000 acre-ft. of ground water annually would deplete the flow of the creek by about 15,000 acre-ft. per year. In order to use the water most efficiently, therefore, it may be necessary to make an adjustment for 15,000 acre-ft. in surface water rights, so as to salvage 85,000 acre-ft. of ground water taken from storage and recharge.

In Beaver Valley, Colo., no surface water supplies are available, and irrigation is entirely by wells. The ground water, however, moves toward the South Platte River, and part of it eventually reaches the stream. If the users of surface water in the South Platte Valley were to be protected fully, all pumping in Beaver Valley would have to be stopped. The pumpage in the valley averages about 20,000 acre-ft. annually. The underflow into the South Platte Valley is about 8,600 acre-ft. annually. As the water levels have declined, the underflow has also declined by probably less than 1,000 acre-ft. annually. The pumping of 20,000 acre-ft. annually would have to be stopped in order to prevent interference with 1,000 acre-ft. of surface water rights.

When irrigation from wells was begun intensively in the South Platte Valley in the 1930's, there was great concern that the wells would cause the river to go dry. There has been no serious lowering of the water level in the valley, even though the pumpage of ground water may exceed 750,000 acre-ft. in dry years. Furthermore, a large part of the land would have been waterlogged if the ground water had not been pumped.

Conclusion

As water demands increase and supply problems become more critical, far-reaching steps will have to be taken for the most efficient utilization of the available supply through careful co-ordination of the use of ground water and surface water. The degree of co-ordination that can be achieved within the framework of present and future legislation will determine how successful the effort will be.

Mother smiled indulgently as Johnny enthusiastically described the many diverting projects he had participated in at summer camp. "I guess you were rather glad to get back home anyway, weren't you, dear?" she ventured.

"Well, not 'specially," the youngster replied. "But some of the fellows were—that had dogs."

"He'll fold in a month. No working capital, overextended on inventory, and an assets-to-liability ratio of only one half to one"

"Young man," the father said sternly, "do you think you should be taking my daughter to night clubs all the time?"

"Indeed not, sir," the swain replied, then added hopefully, "Shall we try to reason with her?"

Missionary: "Do you people know anything about religion?"

Cannibal: "Oh, we got a taste of it when the last missionary was here."

Father looked hard at his wife and then at his son: "That boy has taken money from my pocket."

"How can you say that?" she protested. "Why, I might have done it."

Father shook his head.

"No, you didn't; there was some left."

College Senior (at basketball game): "See that substitute down there playing forward now?"

His Date: "Yes, what about him?"

College Senior: "I think he's going to be our best man next year."

His Date: "Oh, darling, this is so sudden."

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